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Beyond E20

Repositioning Ethanol as India's Transport Energy Backbone



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Foreword by KPMG in India

India's energy transition is entering a decisive phase. As the country balances sustained economic growth with the need to reduce dependence on imported hydrocarbons, the transport sector remains central to this transformation. Liquid fuels will continue to play a critical role in enabling mobility, even as the broader energy mix evolves.

Over the past decade, ethanol has emerged as one of the key pillars in India's energy transitions. What began as a policy intervention to address surplus sugar production and reduce crude import dependence has evolved into a nationally integrated ecosystem linking agriculture, industry, and the fuel distribution network. The achievement of E20 (increased from ~1.5 per cent in Ethanol Supply Year (ESY) 2013–14 to 20 per cent in ESY 2025–26)[1] blending ahead of schedule reflects not only strong policy intent but also the country's ability to execute complex, multi-stakeholder transformations at scale.

This milestone marks the beginning of a new phase. As global energy markets remain volatile and import dependence continues to influence macroeconomic outcomes, domestically produced fuels assume greater strategic importance. The focus is no longer limited to the extent of ethanol blending in petrol; it is shifting toward the role ethanol can play in strengthening the resilience of the transport fuel system. Early developments, including the introduction of flex-fuel vehicles and the rollout of higher-blend fuel infrastructure, indicate that this transition is beginning to move from policy intent toward initial implementation.

Extending the programme beyond E20 will require a structural shift in approach. The systems that enabled rapid scale-up were designed around fixed targets and are largely anchored in First Generation (1G) pathways. The next phase calls for an adaptive framework that expands beyond 1G feedstocks, enables diversified demand pathways, and aligns infrastructure, pricing, and vehicle ecosystems for flexible utilisation. Crucially, ethanol must evolve from a blending component to a balancing lever enabling the transport fuel system to respond to global market conditions.

This report examines how ethanol can be repositioned within India's transport energy landscape and identifies pathways for a central and sustained role.

The progress achieved over the past decade provides a strong foundation. With early deployments already underway, the next phase lies in translating this scale into a system that can deploy ethanol more strategically within India's transport fuel economy.



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1. Iran war brings India closer to its flex fuel moment, Forbes India, dated 04.06.2026

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Executive summary

India's ethanol programme has reached a strategic inflection point. Over the past decade, the Ethanol Blended Petrol (EBP) programme has scaled into a nationally integrated fuel ecosystem spanning agriculture, distillation, Oil Marketing Company (OMC) procurement, logistics, and retail distribution. With the achievement of E20 blending ahead of schedule, ethanol is now embedded within the operating structure of the transport fuel system, rather than functioning as a marginal blending component.

This transition has delivered measurable benefits. Ethanol blending has saved ~ INR1.67 lakh crore in foreign exchange, displaced around 283 lakh metric tonnes of crude oil, avoided nearly 851 lakh tonnes of CO_2 emissions, and supported rural incomes through the ethanol value chain.[2] It has also strengthened the linkage between agriculture and energy, increasing the domestic share of transport fuel value creation.

However, E20 represents a milestone rather than an end-state. Recent policy development, including notification of higher ethanol blending standards (E22–E30) and the recognition of flex-fuel pathways (E85/E100), indicate a transition from a single-blend system to a diversified ethanol-driven fuel architecture.[3,4] Recent developments, including the launch of flex-fuel vehicles across two-wheeler[5] and passenger vehicle segments[6] and the initial rollout of E85 dispensing infrastructure[7], signal early movement toward a multi-grade ethanol fuel ecosystem.

Despite this progress, India's transport fuel economy continues to face structural exposure to global crude price volatility. The challenge extends beyond import dependence to the broader macroeconomic effects of price shocks, reflected in inflation, fiscal pressures, and fuel price variability. Within this context, ethanol is anchored in domestic production and already integrated into the system. It offers the potential to function as a stabilising component within the fuel mix.

The next phase of the ethanol transition is defined by two structural shifts:

- The role of ethanol is expanding from a blending component to a potential transport energy backbone, capable of moderating exposure to external fuel price shocks
- The system that enabled E20 targets relies on fixed blending mandates, administered pricing, and uniform distribution. However, scaling to higher blends like E85 or E100 requires a shift to a multi-grade ecosystem. This entails coordinated readiness across supply, demand, pricing, infrastructure, and vehicle technology.

Importantly, these shifts are built on a foundation that is already in place, with capacity, supply chains, and distribution systems established at scale.

Despite the foundation, several structural constraints limit progress beyond E20:

- **Limitations of 1G feedstock pathways:** Dependence on food-linked and resource-intensive inputs limits scalability
- **Demand limits under fixed blending:** E20 defines a ceiling, with supply beginning to exceed absorption capacity
- **Pricing rigidity in a cost-based framework:** Limited responsiveness to fuel market conditions
- **Infrastructure limitations of uniform delivery systems:** Existing systems are not designed for multi-grade fuel distribution
- **Vehicle ecosystem constraints:** Limited penetration of flex-fuel vehicles restricts higher-blend adoption.

Moving beyond E20 requires a transition toward an adaptive fuel system in which ethanol utilisation responds to global market conditions. Under low price environments characterised by a supply glut, the system remains anchored at baseline blending levels, allowing the fuel mix to benefit from favourable import economics while enabling diversion of ethanol to alternative pathways such as Sustainable Aviation Fuel (SAF).

When global oil supply tightens due to production cuts by major producers such as the Organization of the Petroleum Exporting Countries (OPEC), crude prices tend to rise. In such situations, ethanol can be redirected toward the transport fuel system to reduce exposure to higher import costs, acting as a substitute margin that absorbs part of the price impact through increased utilisation.

2. Achievements of the Ethanol Blended Petrol (EBP) Programme, Government of India (Rajya Sabha – Unstarred Question), dated 09.03.2026
3. Notification - Bureau of Indian Standards (BIS), The Gazette of India, dated 18.05.2026
4. India proposes rules to allow higher ethanol-blended fuels in vehicles, Reuters, dated 29.04.2026
5. Flex Fuel Vehicles offer India a practical solution to reduce crude oil imports, provide additional income to Indian farmers, and advance low-carbon mobility: Sh. Hardeep Singh Puri, Press Information Bureau (PIB), dated 03.06.2026
6. India Goes Flex: Maruti Suzuki launches India's 1st Flex Fuel car, Maruti Suzuki, dated 04.06.2026
7. World Environment Day: India Begins E85 Fuel Rollout, Cleaner Mobility Push Gains Momentum, Outlook Business, dated 05.06.2026

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During periods of acute disruption such as the supply shocks observed in the wake of the Russia–Ukraine conflict and recent geopolitical tensions involving Iran, this flexibility becomes even more critical. Sudden constraints in global supply can lead to sharp price spikes, at which point the system's ability to scale ethanol utilisation through higher pool blends and flex-fuel pathways provides a mechanism to partially offset external volatility.

This dynamic allocation of ethanol across pathways establishes the basis for its role as a stabilising element within the transport fuel system, helping moderate the transmission of global price shocks into the domestic fuel economy.

Operationalising this transition requires coordinated progress across key system dimensions.

- Diversifying the feedstock base beyond 1G pathways, and expanding demand beyond fixed blending limits
- Evolving pricing mechanisms toward a hybrid model that balances market alignment with calibrated stabilisation to manage volatility
- Enabling infrastructure capable of supporting multiple fuel grades
- Strengthening the vehicle ecosystem to support higher-blend adoption through flex-fuel deployment and regulatory alignment.

India has already established one of the world's largest ethanol ecosystems. The challenge ahead lies not in incremental scale-up, but in system-level evolution. The opportunity is to transition ethanol from a successful blending programme to an integrated component of the transport fuel system enhancing resilience, reducing exposure to external volatility, and strengthening long-term energy security.



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01

The build-out: India's journey to E20

India's ethanol blending journey spans over two decades; however, the past decade represents a large-scale system build-out rather than a single policy milestone. The Ethanol Blended Petrol (EBP) programme, launched in 2003, has evolved from inconsistent offtake to a stable, large-scale procurement and blending ecosystem led by Oil Marketing Companies (OMCs). This period marks the acceleration phase of India's ethanol programme.

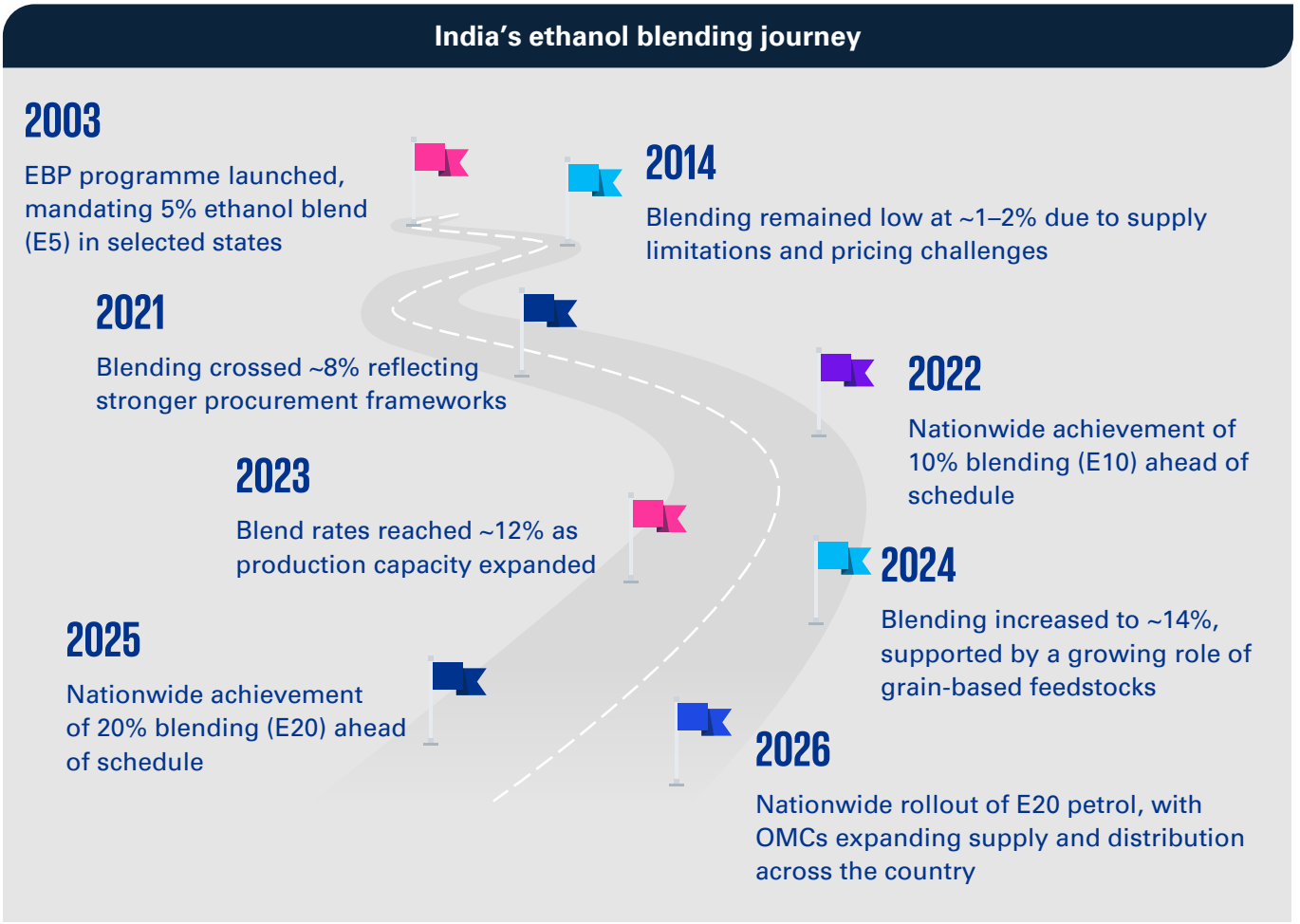


Figure 1: India's ethanol blending journey

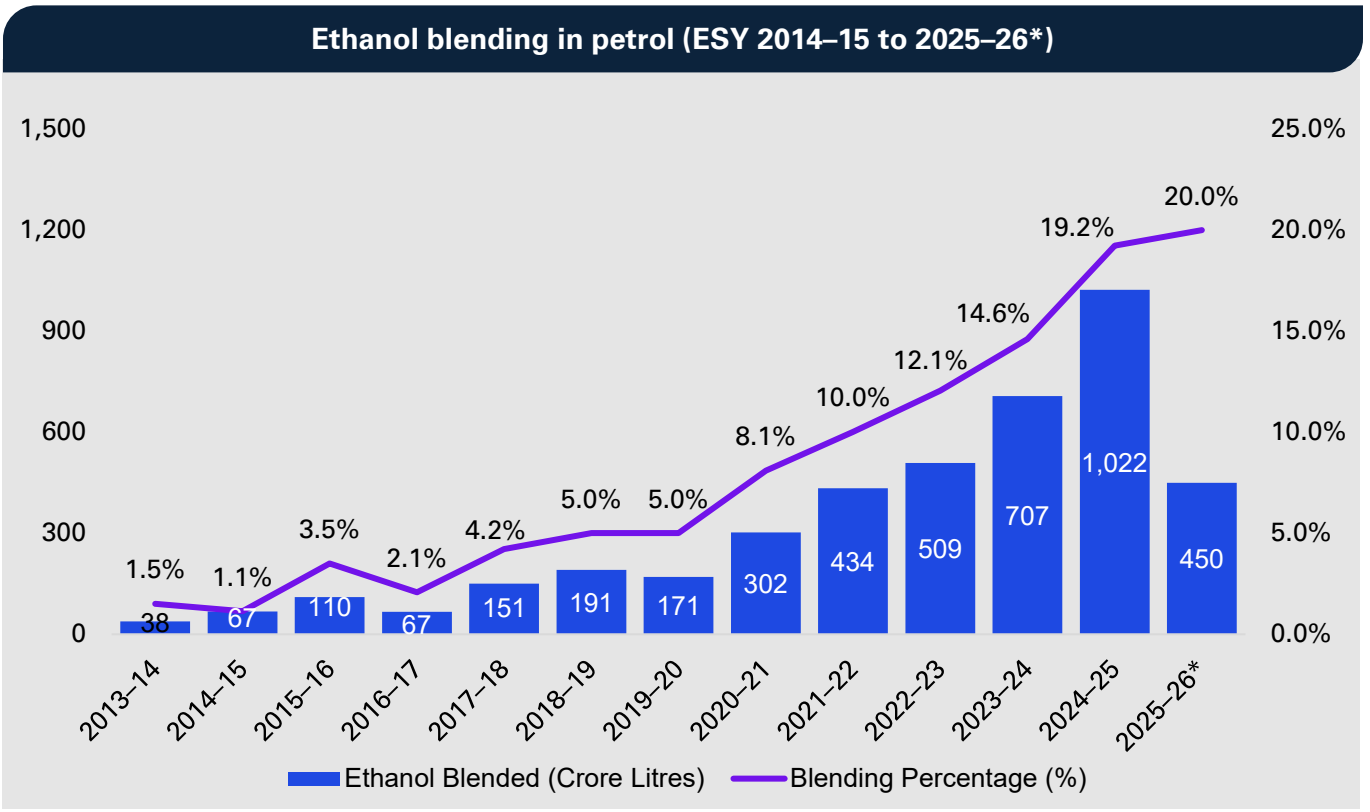
Source: India Climate & Energy Dashboard; NITI Aayog

Blending levels increased from ~1.5 per cent in Ethanol Supply Year (ESY) 2013–14 to 20 per cent in ESY 2025–26[8], achieving the E20 target ahead of schedule. This progress reflects not just policy intent, but the development of an integrated system linking agriculture, processing, and fuel distribution into a single functioning ecosystem. Ethanol is no longer a marginal component in the petrol pool; it is now embedded in the operating structure of India's transport fuel system.



8. Iran war brings India closer to its flex fuel moment, Forbes India, dated 04.06.2026

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** ESY 2025–26 covers the period from November 2025 to March 2026.*

Figure 2: Growth in ethanol blended volumes and blending rates

Source: India Climate & Energy Dashboard; NITI Aayog

The scale-up was enabled by a simple but effective framework: administered pricing, assured OMC offtake, and policy support for distillation capacity expansion. This created predictable demand, stable incentives, and enabled consistent scaling. In practice, this translated into a coordinated build-out across feedstock supply, distillation, logistics, and retail distribution.

Tangible impact at scale

Ethanol blending has delivered measurable outcomes across the economy, with cumulative impact observed from ESY 2014–15 to January 2026:

~283 lakh metric tonnes

of **crude oil** displaced through ethanol blending

~INR1.67 lakh crore

in **foreign exchange** saved by reducing crude imports

~INR 1.47 lakh crore

paid to **farmers** through the ethanol value chain

~851 lakh tonnes

of **CO_2 emissions** avoided through ethanol blending

Figure 3: Key outcomes of EBP programme

Source: Government of India (Rajya Sabha – Unstarred Question)[9]

9. Achievements of the Ethanol Blended Petrol (EBP) Programme, Government of India (Rajya Sabha – Unstarred Question), dated 09.03.2026

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The programme has also absorbed surplus sugar and expanded grain-based ethanol, strengthening feedstock resilience.

Beyond these outcomes, a deeper structural shift is evident. A substantial share of fuel expenditure now remains within the domestic economy, supporting rural incomes and increasing local value capture. Ethanol has introduced a new demand channel for agriculture, catalysed investments in distillation and supply chains, and demonstrated country's ability to execute complex, multi-stakeholder transitions at scale.

Direction for the next phase

With E20 operationalised, the policy focus is shifting beyond a single blending mandate. Emerging higher-blend standards, flex-fuel pathways, and regulatory developments indicate a transition toward a broader fuel architecture. The focus is evolving from target achievement to system design.

This shift is reflected in recent regulatory actions. Standards for E22, E25, E27, and E30 have been notified, while flex-fuel pathways (E85/E100) are now transitioning from policy recognition toward early-stage deployment.[10,11] These developments expand the policy horizon, although large-scale deployment remains at an early stage.

Early signs of this transition are now visible across both vehicle and fuel infrastructure segments, with recent developments indicating movement from policy readiness toward initial implementation:

- **Maruti Suzuki (passenger vehicles):** Introduction of India's first E85-compatible flex-fuel passenger vehicle platform reflects early commercial deployment in the four-wheeler segment, establishing a pathway for higher-blend adoption in personal mobility[12]
- **Hero MotoCorp (two-wheelers):** Launch of flex-fuel two-wheelers marks the extension of FFV deployment into the mass-market mobility segment, enabling gradual build-up of a compatible vehicle base[13]
- **Indian Oil Corporation Limited (IOCL) (fuel infrastructure):** Initial rollout of E85 dispensing infrastructure across select retail outlets provides early operational validation of multi-grade fuel deployment, with the first phase covering around 50 fuel stations across Delhi-NCR, Mumbai, Nagpur, and Pune.[14]

The next phase is not a linear extension of the current model and is already beginning to take shape through these initial deployments across vehicle and fuel infrastructure. The existing system is anchored in fixed blending targets and predictable demand. Scaling beyond E20 requires a more flexible and responsive framework.

This transition entails:

- Moving from fixed targets to demand-linked scaling
- Shifting from administered pricing to market-aligned mechanisms
- Diversifying feedstocks beyond concentrated sources
- Upgrading infrastructure and vehicles for higher blends.

The E20 programme has established the foundation. The strategic question now is whether ethanol can evolve from a successful blending programme into a central pillar of India's transport fuel system.



10. Notification - Bureau of Indian Standards (BIS), The Gazette of India, dated 18.05.2026
11. India proposes rules to allow higher ethanol-blended fuels in vehicles, Reuters, dated 29.04.2026
12. India Goes Flex: Maruti Suzuki launches India's 1st Flex Fuel car, Maruti Suzuki, dated 04.06.2026
13. Flex Fuel Vehicles offer India a practical solution to reduce crude oil imports, provide additional income to Indian farmers, and advance low-carbon mobility: Sh. Hardeep Singh Puri, Press Information Bureau (PIB), dated 03.06.2026
14. World Environment Day: India Begins E85 Fuel Rollout, Cleaner Mobility Push Gains Momentum, Outlook Business, dated 05.06.2026

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02

Strategic pivot: From import substitution to transport backbone

The success of the E20 programme has established ethanol as a scalable component of India's fuel mix. Its role, however, has remained narrowly defined as a tool for import substitution and management of surplus agricultural output.

This framing supported the build-out phase by providing clear direction and ecosystem alignment. As the system matures, its limitations are becoming evident. Positioning ethanol primarily as a volume substitute underestimates the structural challenges in India's fuel system.

The strategic question extends beyond petrol displacement. It is whether India can structurally reduce exposure to global crude price volatility, which continues to drive inflation, fiscal pressure, and fuel price instability. This requires a shift in framing.

The objective is not incremental blending, but repositioning ethanol as a strategic lever within the transport fuel system.

Where ethanol sits in India's transport fuel economy

India's fuel mix is dominated by diesel, followed by petrol. Other fuels including Compressed Natural Gas (CNG)/Liquefied Natural Gas (LNG), Aviation Turbine Fuel (ATF), and electricity (Electric Vehicles - EVs) form smaller but growing segments, while biofuels (ethanol, biodiesel, Sustainable Aviation Fuel - SAF) remain a relatively small component of the overall mix.

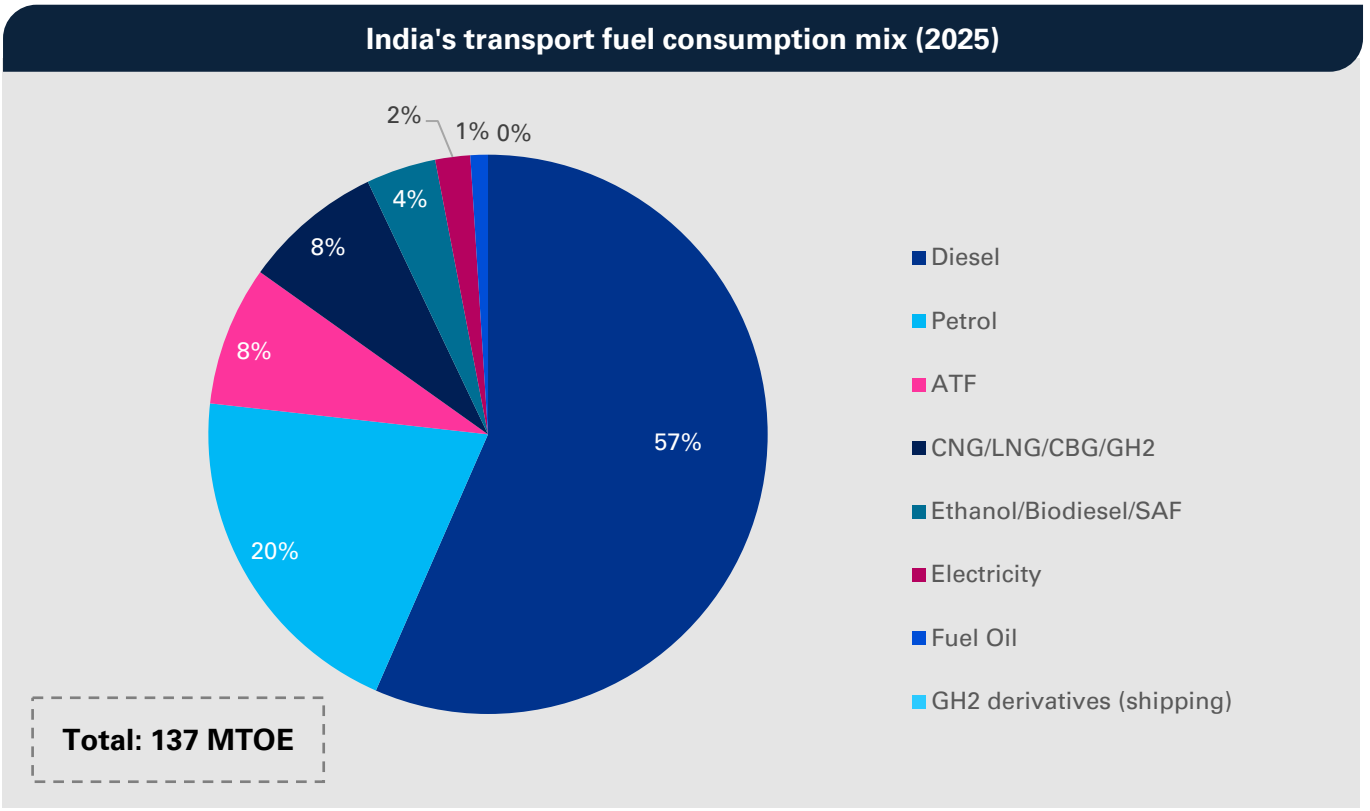


Figure 4: India's transport fuel mix

Source: Sectoral Insights: Transport, NITI Aayog, dated February 2026

Two structural observations emerge from the current distribution:

- **Diesel dominates demand:** Driven by freight, agriculture, and commercial use
- **Petrol is more adaptable:** A smaller but more flexible segment with established blending compatibility.

Looking ahead, liquid fuels will remain structurally relevant across scenarios. The transition is better characterised as a diversification of energy pathways, with electricity and gaseous fuels expanding alongside liquid fuels.

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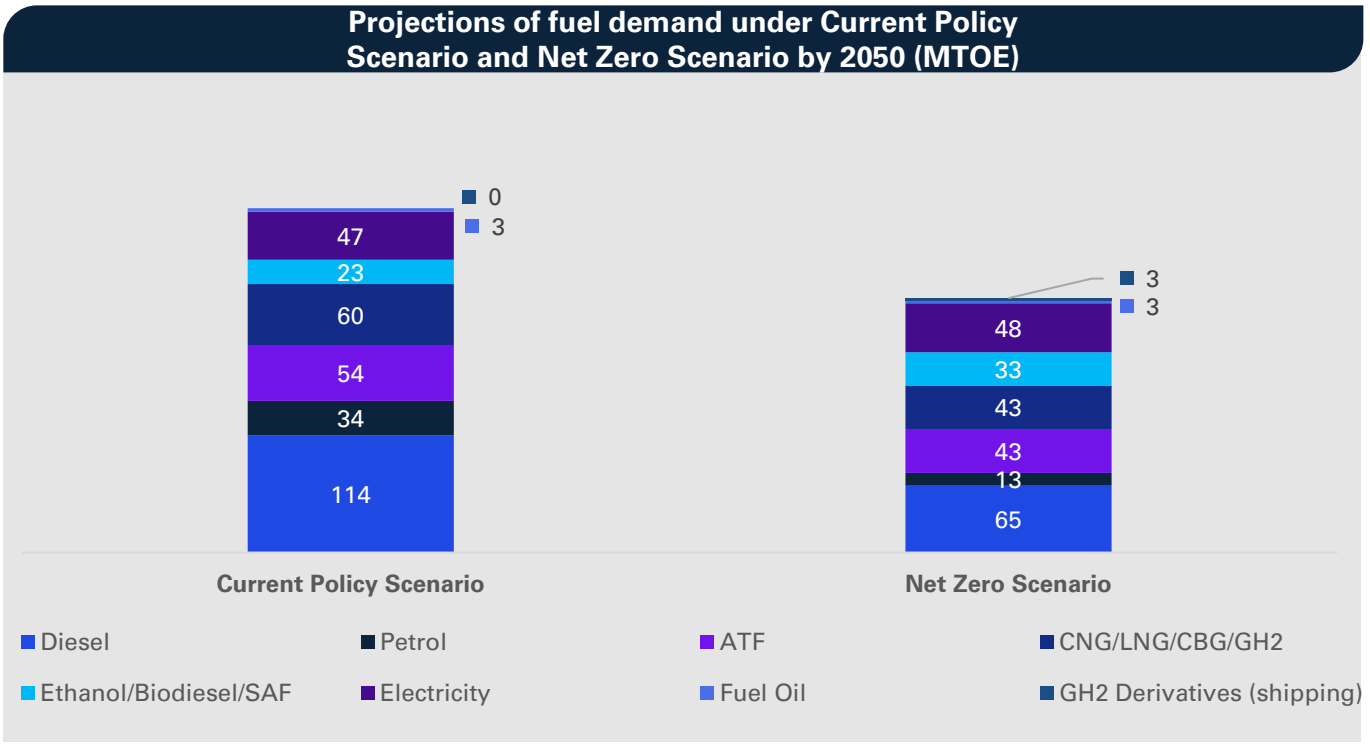


Figure 5: Projected evaluation of transport fuel demand

Source: Sectoral Insights: Transport, NITI Aayog, dated February 2026

Within this evolving fuel mix, ethanol presents a scalable pathway toward lower-carbon transport fuels. Its deployment within the petrol segment where system integration is already established, enables progressive expansion while supporting partial decarbonisation of liquid fuels and increasing the share of domestic supply in transport fuel demand.

However, the diesel segment, while significantly larger, remains structurally constrained, highlighting the limited scalability of earlier fuel alternatives.

The diesel question – why biodiesel did not take off?

Diesel remains the largest segment in India's transport fuel system and the most difficult to substitute.

India's diesel decarbonisation pathway has relied on biodiesel blending, with a 5 per cent target by 2030.[15] However, actual blending remains low at ~0.5 to 0.6 per cent in FY 2024–25.[16,17]

This gap reflects structural constraints rather than limited policy intent.

Feedstock availability

- The biodiesel programme relies primarily on used cooking oil (UCO) and non-edible oilseeds such as Jatropha and Karanja
- UCO availability remains limited and fragmented, with collection systems still evolving and competing uses in oleochemicals and other industries
- Earlier efforts to scale plantation-based feedstocks such as Jatropha have not materialised at scale due to yield uncertainty and weak farmer uptake.

Supply chain integration

- Biodiesel lacks the standardised, OMC-led procurement and distribution model that supported ethanol scale-up
- The dependence on dispersed collection and processing systems has made it difficult to ensure reliable and consistent supply.

Figure 6: Structural constraints limiting biodiesel scale-up in India

15. Government takes multiple steps to safeguard citizens from impact of global crude oil price fluctuations: Petroleum Minister, PIB, dated 21.08.2025
16. Utilisation of Biodiesel, PIB, dated 21.12.2023
17. Indian OMCs Kick Off Biodiesel Procurement for FY 2026 with Major Tender, Autocar Professional, dated 17.04.2025

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These constraints reflect a structural limitation in supply. Given the lack of a scalable feedstock base and an integrated supply chain, biodiesel blending has not achieved consistent, system-wide scale.

Is there an ethanol-diesel synergy?

The limitations of biodiesel as a large-scale solution raise a natural question: whether alternative liquid pathways could play a role in the diesel segment particularly given the increasing availability of ethanol.

Ethanol–diesel blending is technically feasible at low blend levels. Evidence from studies and pilot programmes indicates that blends such as ED5 and ED10 can be deployed without significant engine modifications, while delivering modest environmental benefits.

Key evidence includes:

- **SAE Technical paper (2024):** Reduction in particulate emissions and smoke at low blends (ED7.7 and ED10)[18]
- **Automotive Research Association of India (ARAI) trials in 2018–19:** No major engine failures over extended duration, with marginal efficiency gains[19]
- **Industry pilots:** Indian Oil Corporation Limited (IOCL)-led trials in heavy-duty engines indicating minimal impact on engine torque and power output, alongside a modest improvement of ~2–3 per cent in brake-specific fuel consumption (BSFC).[20]

Scalability remains constrained by technical limitations, including sub-optimal combustion characteristics due to lower cetane value, fuel stability issues arising from poor miscibility, and handling challenges linked to sensitivity to moisture and temperature.

However, the relevance of this pathway extends beyond current feasibility to its potential system role. If ED5 and ED10 can be realised at scale, ethanol–diesel blends could:

- Provide an additional outlet for ethanol supply as production expands beyond petrol blending
- Partially diversify diesel dependency, which remains heavily import-reliant
- Support emissions reduction in segments where electrification is slower.

Ethanol–diesel blending at low concentrations (ED5–ED10) is technically feasible and offers a near-term opportunity to increase clean fuel blending from current ~0.5 per cent to potentially 5–10 per cent. However, large-scale adoption is likely to depend on alignment across fuel standards, handling logistics, OEM endorsement, and clear economic signaling at the pump. In the near term, deployment is likely to be more viable in targeted applications such as captive fleets and commercial segments, with phased scale-up driven by use-case viability rather than uniform national rollout.

Emerging alternatives, such as isobutanol blending, reflect ongoing efforts to diversify diesel decarbonisation pathways.[21] Similar to ethanol, isobutanol is used as a biofuel and can be produced from plant-based feedstocks, while offering improved fuel properties such as better miscibility with diesel. However, its scalability and system integration remain at an early stage.



18. Experimental Investigation of Effect of Various Diesel-Ethanol Blends on In-Use Multi-Cylinder Engine Performance and Emission, SAE Internation, accessed on 28.05.2026
19. Indian government plans 5% ethanol blending in diesel, IBEF, accessed on 28.05.2026
20. Future Transport Fuels for Sustainability: A Step by IOCL towards Net Zero Goals, Indian Oil, dated 08.10.2025
21. India likely to introduce diesel-isobutanol blending mandate this year to boost energy security, ANI, dated 29.05.2026

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What defines ethanol as a transport backbone?

Reframing ethanol as a transport energy backbone rather than a blending mandate rests on three structural characteristics that distinguish it from other fuel pathways:

Scale already exists

India's ethanol installed capacity stands at ~2,200 crore litres (as on May 2026)[22] and blending levels have reached meaningful share of petrol consumption. The system spanning distillation, procurement, and distribution has already been built at scale. While designed around E20, it represents a functioning national infrastructure rather than a greenfield starting point.

The core challenge is price volatility, not just import dependence

The macroeconomic impact of crude is driven less by average import levels and more by volatility in global prices. Price shocks are typically absorbed through a mix of fiscal interventions, OMC balance sheet adjustments, or delayed pass-through to retail prices. In this context, a domestically produced fuel introduces an element of insulation by reducing the direct transmission of global price movements into the domestic fuel economy.

The end-state is energy sovereignty – not a blending target

Blending percentages are an instrument of policy, not the objective itself. The broader objective is a transport fuel system where domestic cost structures play a larger role in determining retail prices, reducing exposure to external supply shocks and geopolitics.

Figure 7: Structural characteristics enabling ethanol's evolution into a transport energy backbone

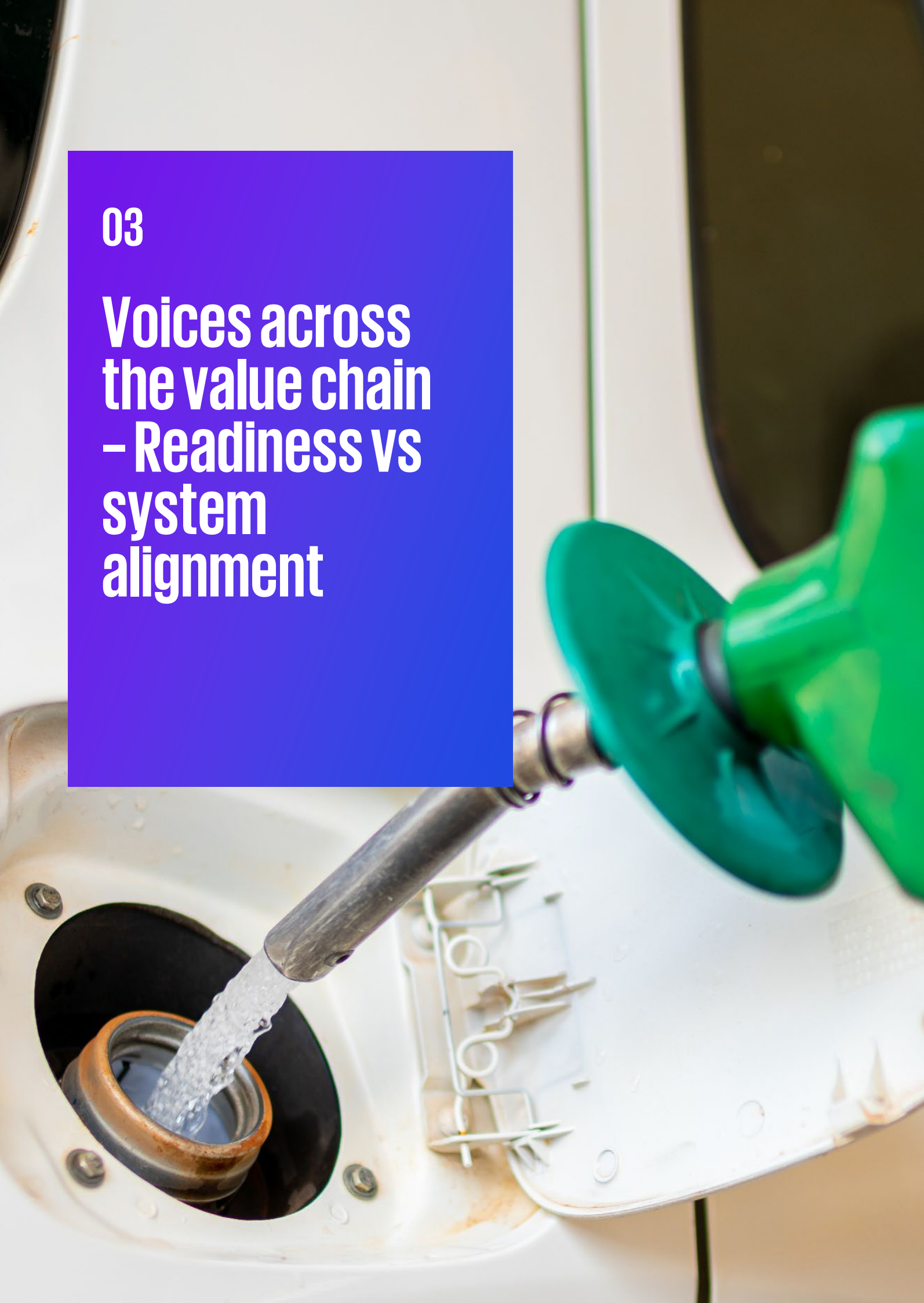
These characteristics build a clear case for ethanol's evolving role within India's transport fuel system. However, the current ecosystem does not fully enable this broader system role. Transitioning to a backbone framework requires coordinated alignment across supply, demand, infrastructure, pricing, and the vehicle ecosystem.

This transition is inherently multi-stakeholder with progress contingent on how participants across the value chain respond to evolving market signals and policy direction.



22. India likely to introduce diesel-isobutanol blending mandate this year to boost energy security, ANI, dated 29.05.2026

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03

Voices across the value chain – Readiness vs system alignment

Progress in the ethanol ecosystem is increasingly shaped by alignment across stakeholders Each segment of the value chain has progressed within its defined role; however, the system as a whole is beginning to exhibit signs of structural misalignment.

The outcomes are increasingly visible:

- Producers that scaled capacity under assured demand are now facing the risk of underutilisation
- OMCs that successfully built infrastructure for E20 are cautious on incremental capex for multi-grade systems
- Original Equipment Manufacturers (OEMs) that have demonstrated technical readiness are hesitant to scale without clear demand visibility for Flex-Fuel Vehicles (FFVs).

The system is therefore at a point where progress within individual segments is no longer translating into system-wide scale.

Ethanol producers: Cautious expansion despite built capacity

Ethanol producers have been among the most responsive participants in the ecosystem, scaling capacity rapidly in response to assured offtake and administered pricing signals. However, the system is now entering a transition phase:

- While higher-blend standards (E22–E30) have been notified, demand beyond E20 is not yet established at scale
- Supply availability is beginning to outpace near-term absorption under current blending levels
- Incremental investments, particularly in Second Generation (2G), carry higher cost and increased policy dependence.

Producers are becoming more selective, prioritising utilisation of existing capacity and deferring new investments, pending clarity on demand expansion from OMCs beyond E20.

OMCs: Calibrated approach to next-phase infrastructure

OMCs have successfully operationalised ethanol blending through a system built around centralised blending and standardised distribution. As the system evolves:

- The transition to higher blends introduces uncertainty on demand location, scale, and timing
- Multi-grade systems require significant retail and supply chain reconfiguration
- Current infrastructure is designed for uniform supply, not differentiated delivery.

OMCs are adopting a phased and calibrated approach to capital deployment, aligning infrastructure investments with evolving vehicle readiness and demand signals. Initial rollout of higher-blend fuels such as E85 has begun in select markets, although large-scale deployment remains contingent on broader ecosystem alignment.



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OEMs: Readiness tempered by ecosystem uncertainty

Automobile manufacturers have demonstrated technical readiness for higher blends with flex-fuel prototypes already developed across segments. However, scale-up remains contingent on:

- Limited passthrough of ethanol pricing benefits to consumers weakens the economic incentive for higher-blend adoption
- Higher upfront cost of FFVs with limited consumer incentives
- Fiscal misalignment, particularly the Goods and Services Tax (GST) differential compared to EVs, increases the cost disadvantage for FFVs.

OEMs are transitioning from limited pilots towards early-stage commercial deployments with recent flex-fuel vehicle launches across segments. However, the scale-up remains contingent on clearer policy alignment and ecosystem readiness.

Consumers: Limited demand pull beyond E20

Consumer adoption has not been a constraint at E20 as the transition has been system-led and behaviourally invisible. Beyond this:

- Higher blends require active fuel choice which is currently not supported by the fuel distribution system
- Adoption is influenced by perceived economic advantage as the pricing benefits of ethanol blending are not fully passed on to consumers, combined with higher upfront costs of FFVs
- Performance trade-offs, such as lower fuel efficiency at higher ethanol blends compared to petrol, affect decision-making in the absence of compensation for mileage loss.

Consumers have not yet shown interest in higher blends which limits the pace at which availability translates into actual uptake.

These perspectives point to a common conclusion. The constraint is no longer the readiness of individual stakeholders but the alignment of the system. While ethanol blending delivers macroeconomic benefits through reduced import dependence, the associated cost advantages are not fully transmitted to end consumers. Instead, value capture remains concentrated upstream across distillers and OMC procurement, limiting the emergence of a strong consumer-driven demand signal.

At the same time, early developments across segments, including the initial rollout of higher-blend fuels and the introduction of flex-fuel vehicles, indicate that elements of system alignment are beginning to emerge. However, these remain limited in scale and are yet to translate into coordinated, system-wide adoption.

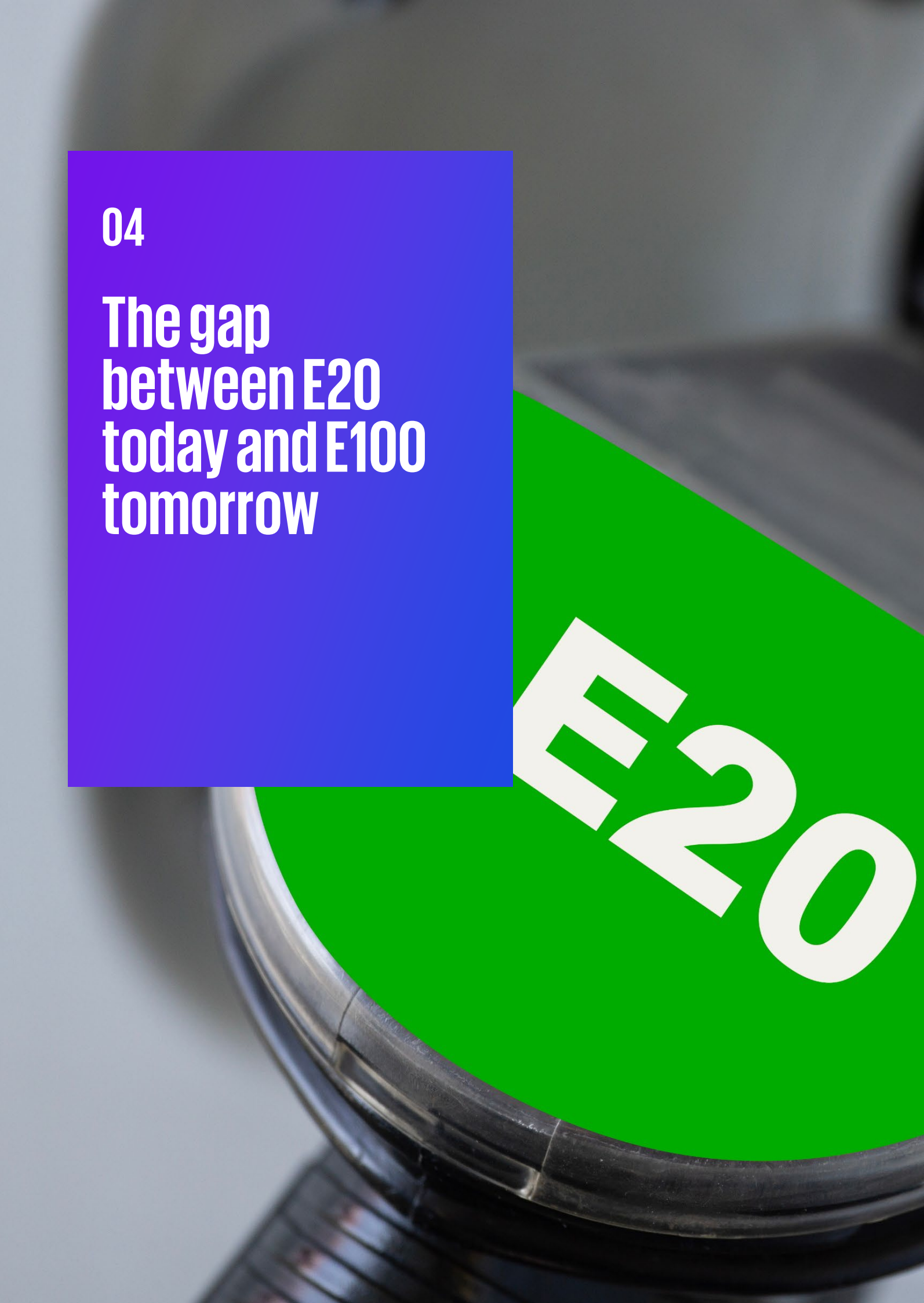
Progress beyond E20 will depend on aligning incentives across the value chain. This includes ensuring that pricing mechanisms transmit benefits to end users, alongside coordinated evolution in infrastructure, vehicle deployment, and policy frameworks. Achieving this alignment is expected to allow investment, supply, and consumer adoption to progress in tandem, enabling the next phase of scale.



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04

The gap between E20 today and E100 tomorrow



The achievement of E20 demonstrates that ethanol can be scaled nationally within a fixed blending framework. It confirms the ability to coordinate supply, procurement, and distribution at scale.

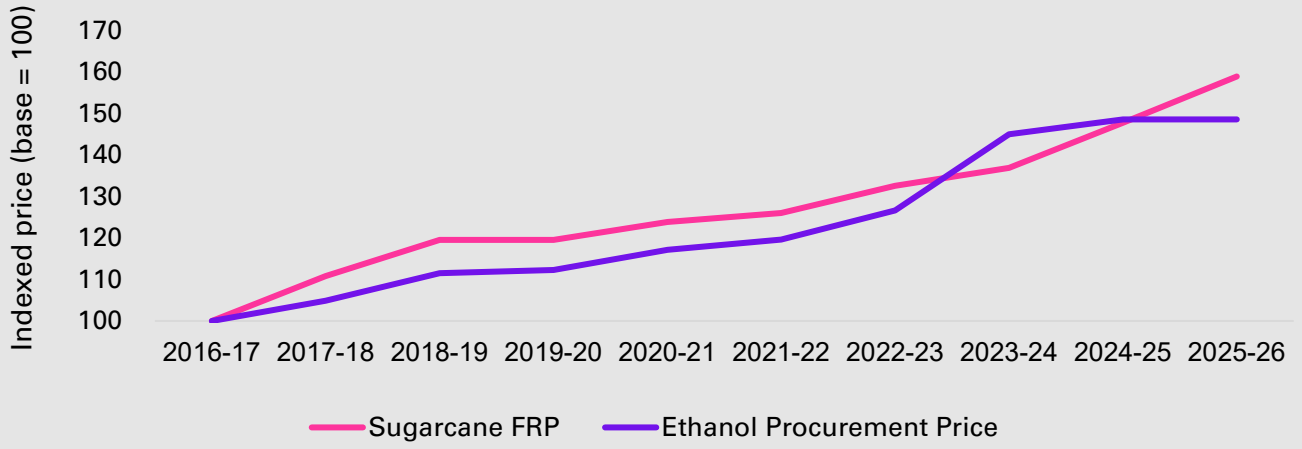
However, the transition beyond E20 is not a linear extension of the current model. Higher blends such as E85 or E100 require a different level of system readiness across supply, demand, pricing, infrastructure, and the vehicle ecosystem.

The gap is structural and can be assessed across five dimensions:

1. Feedstock constraints beyond 1G pathways

E20 has been scaled through 1G feedstocks under an administered procurement framework, where ethanol procurement prices are periodically aligned with increases in sugarcane Fair and Remunerative Price (FRP) to sustain producer viability.

Sugarcane FRP vs. ethanol procurement price (C-Heavy Molasses), indexed to 2016-17 base



Note: Sugarcane FRP (INR/quintal) and ethanol procurement price (INR/litre) are indexed to a common base year (2016–17 = 100) to enable comparison of relative price movements.

Figure 8: Sugarcane FRP vs. ethanol procurement price (C-Heavy Molasses) under administered pricing framework

Sources: Sugar Policy, Department of Food and Public Distribution; PIB

Indexed trends indicate that ethanol pricing has largely moved in line with FRP, driven by periodic policy revisions. This reflects a system where producer viability is maintained through administrative price alignment, rather than through market-driven signals.

However, this framework operates independently of global fuel markets. While ethanol prices are linked to domestic feedstock costs such as FRP, transport fuel prices are ultimately influenced by global crude dynamics.

As FRP increases, ethanol procurement prices are periodically adjusted under the administered framework to sustain producer viability. However, this creates a structural disconnect between domestic cost movements and global price signals. This becomes particularly evident in scenarios where crude prices decline sharply, potentially making ethanol-driven blends relatively more expensive within the retail fuel mix.



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Given that FRP follows a cost-plus mechanism and tends to move upward over time, ethanol pricing correspondingly tracks this trajectory through policy-driven revisions, limiting alignment with market conditions.

In addition, price adjustments operate with inherent lags due to their policy-driven nature. This reduces responsiveness to real-time movements in both domestic costs and global crude prices. As blending levels increase, the scale of intervention required to maintain this alignment also expands. Rising feedstock costs necessitate corresponding increases in ethanol procurement prices, amplifying downstream impacts on fuel pricing. This makes continued reliance on 1G pathways progressively more complex at higher scales.

In addition to these pricing constraints, structural pressures on feedstock availability and resource intensity further limit the scalability of 1G pathways:

- **Food-versus-fuel arithmetic:** Scaling ethanol production through grain diversion raises concerns about competing uses at higher volumes
- **Resource intensity of sugarcane:** Ethanol production from sugarcane is highly water-intensive (around 2,860 litres of water per litre of ethanol)[23], making large-scale expansion increasingly resource-constrained.

These constraints strengthen the case for alternative pathways such as 2G ethanol, which enable supply expansion without placing additional pressure on feedstock supply or resource use.

2G ethanol produced from agricultural residues, woody biomass, and Municipal Solid Waste (MSW) addresses these structural constraints by diversifying feedstocks. However, its economics remain misaligned with the current 1G-led procurement framework:

- **Higher production costs:** Typically, 20–40 per cent costlier than 1G, driven by enzyme intensity and process complexity, though costs are expected to decline with scale and technology maturation.[24]

These higher costs are currently supported through policy interventions such as Viability Gap Funding (VGF) and assured offtake, enabling project viability in the absence of cost competitiveness. As a result, economics of 2G ethanol remain contingent on policy support rather than being structurally embedded within the procurement framework.

India currently has a limited base of commercial 2G capacity (~485 Kilo Liters Per Day (KLPD) across four plants) , reflecting the early-stage nature of this transition.



Figure 9: Current 2G ethanol production footprint by feedstock and location

Sources: Government of India (Lok Sabha – Unstarred Question)[25]

23. Roadmap for Ethanol Blending in India 2020-25, NITI Aayog, dated June 2021
24. Second-Generation (2G) Biofuels in India: What's Next Beyond Ethanol?, Advance Biofuel, accessed on 29.05.2026
25. Performance of 2G Ethanol Plants, Government of India (Lok Sabha – Unstarred Question), dated 05.02.2026

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2. Demand limits under fixed blending

The current ethanol ecosystem is anchored around a fixed blending mandate with E20 effectively defining the upper bound of demand within the petrol pool. This design has enabled rapid scale-up through demand certainty but inherently creates a ceiling once the target is reached.

In the ESY 2025–26 Cycle-1 tender, ethanol supply offers (~1,776 crore litres) significantly exceeded OMC requirements (~1,050 crore litres)[26], reflecting the demand ceiling imposed by the E20 blending cap. This indicates that supply availability is beginning to outpace demand under current blending levels.

Historically, volumes beyond this level have had limited absorption pathways outside the mandated framework. Recognising this, recent policy developments enabling higher blends such as E22, E25, E27, and E30[27] signal a shift toward expanding demand beyond E20 and transitioning to a more graduated blending architecture.

However, this transition remains at an early stage. In the absence of a clearly sequenced and scalable pathway beyond E20, supply growth is likely to continue outpacing demand creation.

3. Pricing rigidity in cost-based framework

The current ethanol ecosystem operates under an administered, cost-based pricing framework, where procurement prices are derived using feedstock costs along with assumptions on conversion costs, capital recovery, and returns. This has enabled rapid scale-up by ensuring producer viability and reducing investment risk.

As the system evolves beyond E20, this structure may show below potential limitations:

Policy-led price revision framework	Prices are revised periodically through policy decisions, rather than adjusting in real time to changes in input costs.
Limited responsiveness to demand–supply conditions	Prices are not directly linked to surplus or shortage conditions, which may affect how the system responds as capacity expands.
Absence of market-based balancing	The framework provides limited price signals for incremental supply to be absorbed, redirected, or differentiated across end-use pathways.
Weak linkage to downstream fuel economics	Ethanol pricing remains largely disconnected from petrol prices and consumption patterns which may affect its role as a balancing lever within the transport fuel system.

Figure 10: Limitations of the administered pricing framework

These limitations have not constrained the system to date, given the focus on achieving a defined blending target. However, as supply begins to outpace fixed demand, the absence of pricing flexibility limits the system's ability to rebalance efficiently.

In essence, the current pricing model ensures cost alignment but lacks market responsiveness. It is well-suited to delivering a fixed blending target, but not to enable a system where ethanol can respond dynamically to evolving supply–demand conditions.

26. ESY 2025-26: OMCs receive 1,776 crore litres offer for ethanol supply against requirement of 1,050 crore litres, BioEnergy Times, dated 08.10.2025

27. Notification - Bureau of Indian Standards (BIS), The Gazette of India, dated 18.05.2026

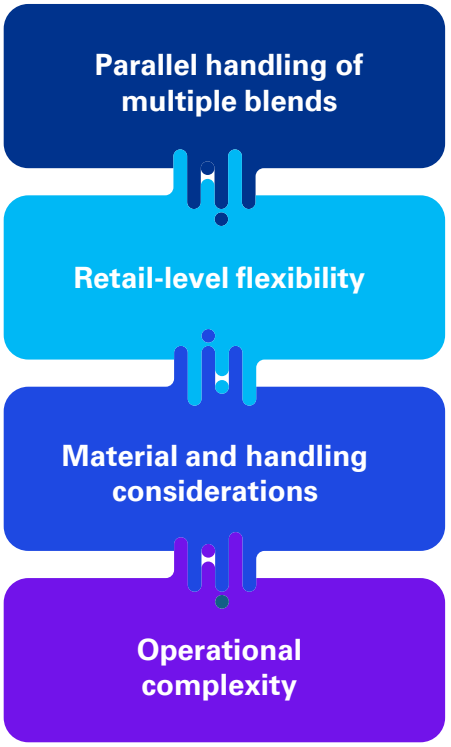
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4. Infrastructure limits of uniform delivery systems

The infrastructure built under the E20 programme is designed around a centrally blended, uniform fuel model, delivering a standardised product across the distribution network. This has enabled rapid scale-up by simplifying logistics, ensuring consistency, and minimising operational complexity.

However, transitioning towards higher blends requires a different operating model.

Higher blends necessitate a multi-grade fuel system, where multiple ethanol–petrol blends coexist within the same supply chain and are delivered selectively based on demand. This introduces new requirements across the infrastructure layer:



Storage, transport, and distribution systems must handle E20, E85, and potentially E100 simultaneously, requiring segregation across the value chain.

Fuel stations must be equipped to store and dispense multiple fuel grades, rather than a single standardised product.

Higher ethanol blends require adaptations across storage tanks, pipelines, and dispensing equipment.

Logistics shift from a centralised blending model to a more flexible, potentially decentralised system.

Figure 11: Infrastructure constraints to higher ethanol blends

This transition is significant given the scale of India's fuel distribution network, with close to 100,000 fuel stations, including approximately 90,600 operated by public sector OMCs.[28] Even incremental upgrades therefore translate into substantial system-wide effort.

While the current infrastructure is fit for delivering E20 at scale, it is not designed for a multi-grade, demand-responsive system. The initial rollout of E85 dispensing infrastructure across select locations reflects the early stages of this transition.

5. Vehicle ecosystem constrained by compatibility

The ethanol blending programme in India has been designed to ensure backward compatibility with the existing vehicle fleet, enabling nationwide rollout of E10–E20 without requiring large-scale changes to engines or fuel systems. This approach has enabled rapid adoption by avoiding disruptions for consumers and OEMs.

However, this compatibility-led model also defines the limits of the current system.



28. India may soon let consumers choose ethanol-blended petrol based on their cars: Report, Economic Times, accessed on 29.05.2026

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However, this compatibility-led model also defines the limits of the current system.

1 Deployment, not technology readiness

Higher ethanol blends require FFVs capable of operating across a wide range of ethanol–petrol mixtures.

Notably, leading OEMs (Toyota Kirloskar Motor, Maruti Suzuki, Mahindra & Mahindra, and Hyundai Motor India, among others) already have FFV prototypes in place, with pilot and demonstration models indicating strong technology readiness.

However, commercialisation remains potentially constrained by:

- Limited availability of compatible fuels
- Absence of clear adoption roadmap
- Lack of alignment across infrastructure, pricing, and policy.

2 Fleet turnover dynamics

A key limitation in scaling higher ethanol blends is the slow turnover of the existing vehicle fleet, which delays the impact of new technologies like FFVs.

- Vehicles typically remain in use for 10–15 years
- Annual passenger vehicle sales (~4.7 million units in FY2026)[29] represent a small incremental addition to the overall fleet, reinforcing the slow turnover of the existing vehicle base.

As a result, even with accelerated FFV rollout, fleet-level penetration builds gradually, creating a lag between fuel availability and actual demand.

3 OEM and policy alignment

Scaling FFVs depends on clear demand visibility and supportive policy signals, which remain uncertain in the current system.

- OEM investments are influenced by demand clarity and long-term adoption signals
- Current fiscal treatment differs across vehicle pathways, with GST on FFVs at 28 per cent compared with 5 per cent for EVs,[30] affecting relative consumer pricing and adoption dynamics.

4 Consumer adoption dynamics

Beyond E20, adoption shifts from passive consumption to active fuel choice, introducing new behavioural and economic considerations.

- Consumers face fuel efficiency trade-offs due to lower energy density of ethanol
- Adoption depends on awareness, confidence, and perceived cost-benefit.

This introduces an additional layer of friction, slowing the transition from availability to actual usage.

Figure 12: Key potential constraints to scaling higher ethanol blends

Taken together, these constraints indicate that the transition beyond E20 is not limited by vehicle technological capability, but by the pace of evolution in the overall ethanol ecosystem.

Moving beyond this stage requires a coordinated, system-level shift, enabled through a set of core pillars that address these potential constraints in an integrated manner.

29. FADA Releases FY'26 and March'26 Vehicle Retail Data, FADA, dated 06.04.2026

30. Govt eyes flexible fuel vehicles' faster roll out, Times of India, dated 30.03.2026

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05

The five pillars of an ethanol energy backbone

Repositioning ethanol as a transport energy backbone requires moving beyond a single blending objective toward a system supported by multiple, reinforcing pillars. These pillars reflect the structural dimensions through which ethanol integrates into the broader fuel economy.

Individually, each pillar represents a distinct component of the system. Together, they define the conditions under which ethanol can function as a stable and scalable energy pathway.

Pillar 1: Feedstock diversification towards scalable supply

Scaling ethanol beyond E20 requires a transition from a 1G-dominated supply base to a more diversified feedstock ecosystem. The current model, anchored in sugarcane and food grains, is constrained by competing uses and resource intensity.

Within this framework, 1G ethanol remains foundational, providing a reliable production base and supporting established rural income streams.

However, sustaining growth beyond E20 cannot rely solely on 1G pathways.

To support this transition, India's non-food feedstock potential spans agricultural residues, MSW, and UCO, distributed across regions. These diverse and dispersed feedstocks collectively form the basis for scaling 2G ethanol where viability depends on the ability to aggregate and integrate them into organised supply chains. Agricultural residues, in particular, remain fragmented, requiring structured collection and aggregation models such as hub-and-spoke systems to enable efficient feedstock mobilisation and support expansion of 2G capacity.

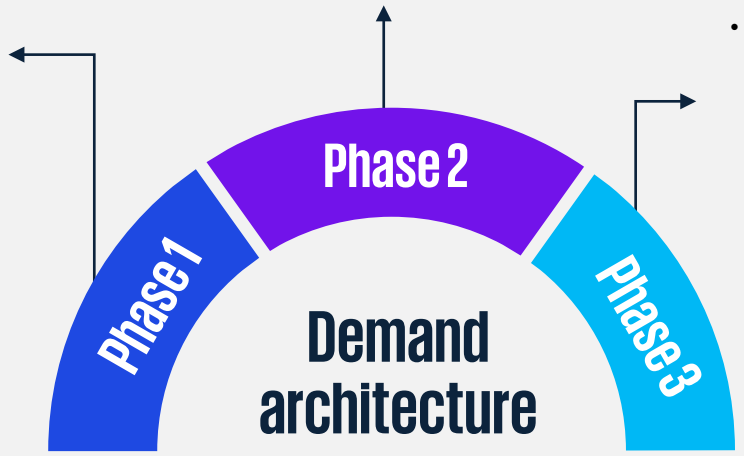
Taken together, the supply system evolves toward a layered structure, with 1G anchoring base supply and 2G enabling incremental growth. This transition is critical to scaling ethanol beyond current blending levels without introducing upstream constraints.

Pillar 2: Demand architecture beyond the E20 ceiling

Demand for ethanol beyond E20 does not emerge automatically; it evolves through a sequenced progression of blends, infrastructure, and vehicle adoption.

- The first phase builds on the progression from E20 to higher intermediate blends. The notification of E22, E25, E27, and E30 expands the operating range within the petrol pool, allowing ethanol utilisation to move beyond a single fixed level[31]
- Within this progression, intermediate blends serve as a transition step, supporting gradual system evolution as vehicle compatibility and infrastructure readiness improve.

- The second phase centres on the E85 ecosystem, driven by the expansion of FFVs and dedicated dispensing infrastructure
- At this stage, demand begins to diversify across compatible segments, with higher blends gaining share as fuel economics and system readiness align. While the initial impact remains incremental, it becomes progressively more material as FFV penetration scales.



- The final phase represents a more advanced configuration, where very high blends (including E100) are adopted in specific segments such as urban clusters and fleet applications
- These are supported by dedicated infrastructure and a mature vehicle ecosystem. International experience, particularly in markets like Brazil, illustrates how such systems can scale over time, with FFVs accounting for ~74% of new light vehicle registrations in 2025,[32] supporting widespread adoption of higher blends.

Figure 13: Phased expansion of ethanol demand

31. Notification - Bureau of Indian Standards (BIS), The Gazette of India, dated 18.05.2026

32. Sugar Lobby Pushes for E22 Transition, Flex-fuel Policy as Ethanol Overcapacity Bites, Autocar Professional, dated 06.04.2026

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At India's current passenger vehicle sales pace of ~4.7 million units annually (FY2025–26)[33], even a 5–10 per cent FFV penetration would add only ~0.2–0.5 million FFVs each year. Given that vehicles remain in use for extended periods, with annual sales representing only an incremental addition to the overall fleet, adoption is expected to scale gradually as the fleet is progressively replaced and expanded over time.

This implies a steady but slow build-up in FFV penetration, with volumes reaching levels that support phased E85 rollout, initially in high-demand urban clusters. Over the longer term, the transition toward higher blends such as E100 within specific segments provides an additional demand layer, supporting sustained growth in ethanol utilisation as fleet composition continues to evolve.

Early indicators of this transition are now visible. The introduction of flex-fuel vehicles across both two-wheeler and passenger vehicle segments marks the beginning of a gradual build-up in compatible vehicle stock. In parallel, initial rollout of higher-blend fuels such as E85 is creating early pathways for demand beyond E20. While limited in scale, these developments represent the first structural enablers of incremental demand expansion.

This highlights that the evolution of ethanol demand is not a single-step transition, but a phased expansion aligned with system readiness. Each stage builds on the previous one, gradually extending the role of ethanol from a blending component within the petrol pool to a more diversified and scalable element of the transport fuel system.



33. FADA Releases FY'26 and March'26 Vehicle Retail Data, FADA, dated 06.04.2026

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Pillar 3: Pricing transition toward market responsiveness

Pricing remains the critical structural lever within the system, as it determines whether relative fuel economics translate into actual market behaviour. In its current form, the ethanol pricing framework is anchored in administered procurement prices, which ensure producer viability but limit responsiveness to broader fuel market conditions.

An evolved approach requires a transition toward a more integrated and responsive pricing structure. This can be conceptualised as a layered architecture that retains the strengths of the existing system while introducing greater flexibility and market alignment.

This layered framework builds on the current model while addressing its key limitations:

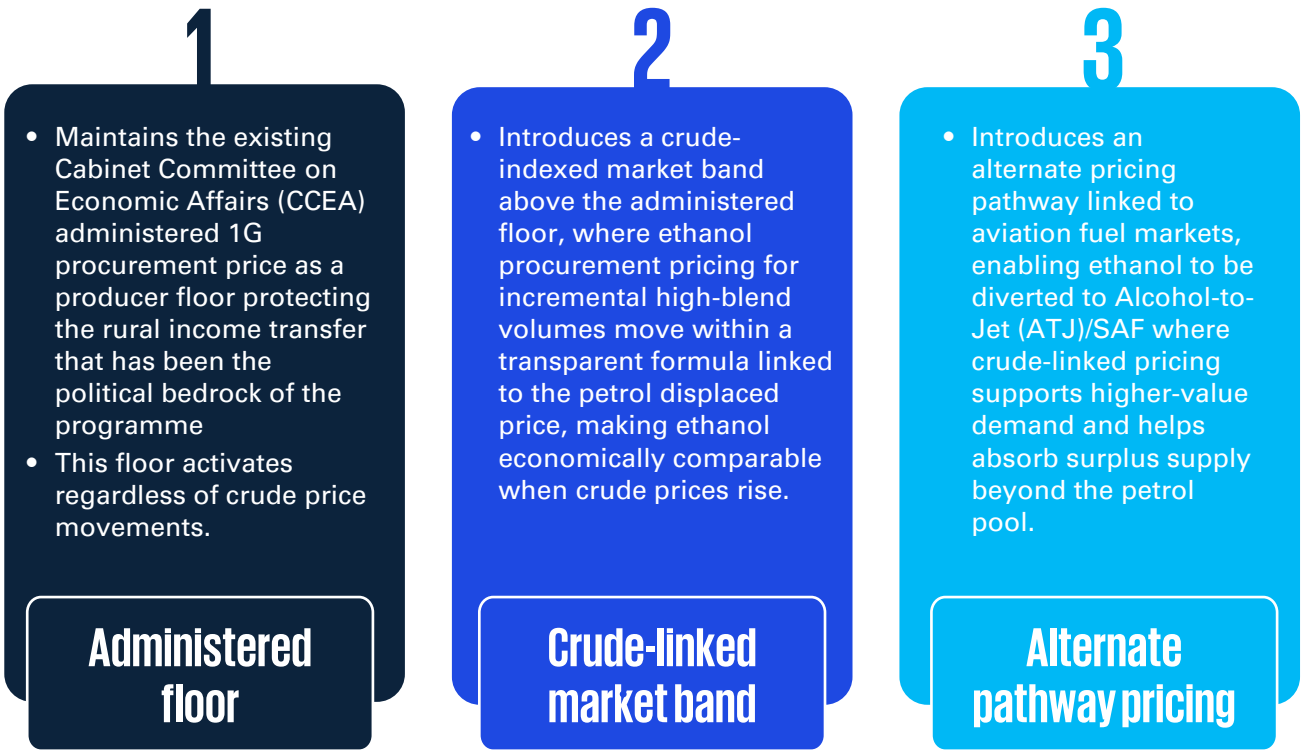


Figure 14: Evolving ethanol pricing architecture

A layered pricing architecture bridges the gap between stability and responsiveness, ensuring that producer economics remain protected while enabling the system to adapt dynamically to evolving market conditions.

Pillar 4: Infrastructure shift to multi-grade systems

A transport energy backbone requires infrastructure that can support multiple pathways of ethanol use, rather than a single standardised blend. A system designed for one uniform fuel delivery must progressively evolve to accommodate:

- Dedicated dispensing systems for different blends
- Segregated underground storage
- Advanced blending and handling controls
- Fuel-quality monitoring mechanisms for multiple ethanol variants.

This transition is inherently complex given the scale of the existing retail network and is unlikely to occur through a simultaneous nationwide retrofit. Instead, infrastructure development is expected to follow a phased and selective approach with deployment prioritised in locations where vehicle readiness, demand concentration, and economic viability are aligned.

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This transition is already beginning to take shape. The government has outlined plans to establish around 5,000 E100 dispensing stations across the country over the next two years, with an initial rollout in major urban centres and subsequent expansion across regions.[34] Early deployments, including the rollout of E85 dispensing infrastructure by Indian Oil Corporation Limited across select retail outlets, provide initial operational validation of a multi-grade system. This indicates a shift from pilot-scale deployment toward building a broader infrastructure base for higher ethanol blends.

In this context, infrastructure becomes more than a physical enabler. It determines when and where higher ethanol blends can be deployed at scale, effectively connecting notified blending standards with actual market availability. As the system moves beyond E20, infrastructure therefore acts as the critical bridge between policy intent and operational reality.

Pillar 5: Vehicle transition toward capability-led adoption

The evolution of the vehicle ecosystem is a critical determinant of ethanol's scalability beyond current blending levels. Higher ethanol utilisation depends on the expansion of a compatible vehicle base, particularly through the adoption of FFVs.

Recent policy developments signal a clear directional shift. The government has proposed amendments to the Central Motor Vehicles Rules to formally recognise E85 and E100 as primary transport fuels and incorporate them into the emissions testing framework. This establishes the regulatory foundation for higher-blend adoption and enables homologation of vehicles capable of operating on these fuels.

However, the real constraint lies in translating this policy architecture into large-scale vehicle deployment. Early-stage commercial deployment of flex-fuel vehicles has begun across both two-wheeler and passenger vehicle segments. However, a meaningful base of vehicles capable of utilising higher blends has yet to emerge at scale. Given the pace of fleet turnover, expansion of the compatible vehicle base is likely to be gradual, with current deployments representing the initial foundation for future demand.

A key barrier remains the fiscal treatment of FFVs. The current GST differential, with FFVs taxed at 28 per cent compared to 5 per cent for EVs22,[35] weakens the relative economics of large-scale deployment and reduces OEM incentives to scale production.

From a consumer perspective, adoption remains limited by weak economic incentives and limited availability. Higher blends require active fuel choice, which is not yet supported at scale, while the pricing advantages of ethanol are not fully passed through to end users. Combined with higher upfront costs of FFVs and performance trade-offs such as lower fuel efficiency, this constrains consumer interest and slows demand formation.

While recent vehicle launches mark an important shift from readiness to deployment, scaling adoption will likely depend on stronger alignment across fuel availability, pricing, and policy support. Translating early deployments into a meaningful vehicle base will be critical to enabling higher ethanol utilisation beyond current blending levels.

Translating system alignment into a functional equilibrium

Taken together, these five pillars describe the conditions under which ethanol can evolve from a policy-led blending input into a more structural component of the transport fuel system. Each pillar addresses a different potential constraint, including feedstock, demand, pricing, infrastructure, and vehicle capability, but their significance lies in how they interact.

Ethanol can assume a broader system role when the ecosystem operates in alignment. This enables dynamic ethanol utilisation to respond to underlying fuel economics and adjust in line with changing market conditions rather than remain fixed.

This gives rise to a system-level equilibrium within the transport fuel sector, where ethanol expands or contracts its role based on relative economics. In turn, ethanol functions as a balancing lever, moderating the impact of external price movements and supporting overall system stability.



34. Govt Plans To Set Up 5,000 E100 Fuel Stations In Two Years To Reduce Import Reliance, The Free Press Journal, dated 20.05.2026

35. Govt eyes flexible fuel vehicles' faster roll out, Times of India, dated 30.03.2026

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06

Ethanol as a crude shock buffer: The equilibrium mechanism



Ethanol introduces a potential stabilising mechanism within India's transport fuel system by partially decoupling fuel demand from global crude price volatility.

Currently, crude price shocks are absorbed either through retail price freezes shifting the burden to OMC balance sheets or passed through to consumers as inflation. The growing availability of domestically produced ethanol creates an alternative pathway, enabling partial substitution of petrol and moderating exposure to external price movements.

In this framework, ethanol is not limited to a blending role, but functions as a structural lever influencing system-level price dynamics during periods of elevated crude prices.

How the mechanism works

The effectiveness of this mechanism depends on a shift from fixed blending levels to a more responsive utilisation framework. Instead of operating a static blend such as E20, the system adjusts ethanol use within defined boundaries based on external conditions, particularly movements in the India crude basket prices.

Under low crude price environments, characterised by stable or oversupplied global markets, ethanol utilisation remains anchored at baseline blending levels. This allows the system to benefit from favourable import economics while avoiding cost escalation within the domestic fuel mix.

As crude prices rise, the economics of ethanol become increasingly competitive relative to petrol. This creates an opportunity to expand ethanol utilisation within the transport fuel pool, enabling partial substitution of petrol and moderating the impact of higher import costs.

During periods of acute supply disruption or sharp price spikes, this flexibility becomes more critical. The system can respond by scaling ethanol utilisation through higher pool blends and flex-fuel pathways providing a mechanism to partially offset external volatility.

In parallel, during periods of surplus supply or weaker demand within the transport segment, ethanol can be redirected toward alternative pathways such as Sustainable Aviation Fuel. This provides a balancing mechanism, allowing supply to shift across sectors based on relative economics and demand conditions.

This response unfolds through two parallel channels, each with a distinct role in the system:

1 Pool blend (system-wide impact)

This channel operates through the progressive adoption of higher blends within the petrol pool building on already notified standards. As the system evolves:

- Blend levels can move beyond E20 toward E25 and E30
- Such shifts apply across the entire distribution network
- All vehicles continue to consume the blended fuel without requiring behavioural change.

Role:

- Enables immediate, system-wide adjustments in ethanol utilisation within existing constraints
- Provides a broad-based lever to increase ethanol utilisation within the compatibility limits of the existing vehicle fleet.

2 E85 channel (FFV-linked expansion)

This channel operates through a segmented pathway tied to FFVs. Higher blends such as E85 are delivered through dedicated dispensing infrastructure and are consumed by FFVs capable of operating across a wide ethanol range.

In this channel:

- Uptake is influenced by relative fuel economics
- Utilisation increases gradually as higher blends become more attractive.

Role:

- Provides a scalable expansion pathway linked to FFV adoption
- Enables a demand-responsive layer where ethanol use expands based on price signals rather than mandates. Scale grows progressively with FFV penetration.

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Together, they allow ethanol utilisation to increase both uniformly and incrementally, depending on technological, infrastructure, and market conditions.

This layered design differentiates the architecture from earlier biofuel approaches in India by moving beyond a single fixed blending mandate to a dual-channel system, one system-wide and the other FFV-linked, each scaling at a different pace.

Over time, the mechanism strengthens as the FFV base expands without requiring changes to the underlying framework. Each incremental increase in ethanol utilisation through higher pool blends or greater E85 uptake directly displaces imported petrol, especially during periods of elevated import costs.

The four institutional design elements

The functioning of this mechanism is not automatic. Its effectiveness depends on the presence of enabling institutional design elements that allow the system to respond in a coordinated and calibrated manner.

These elements do not represent discrete interventions, but structural characteristics that shape how effectively ethanol can perform a stabilising role within the transport fuel system.

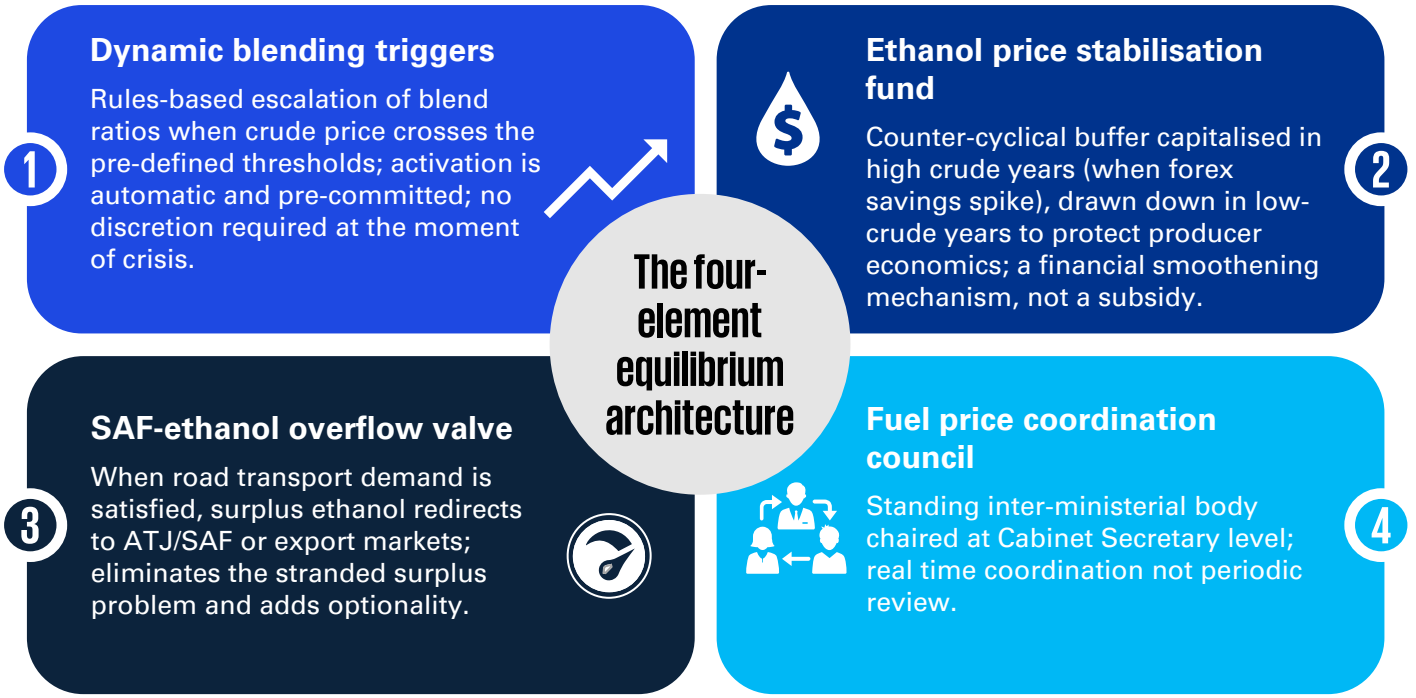


Figure 15: Institutional design elements



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Why this works when static mandates do not

Static blending mandates are calibrated to average conditions, while fuel markets are inherently volatile. As a result, fixed blend levels such as E20 can be misaligned, constraining producer economics in low-crude environments and limiting substitution potential when crude prices rise.

The proposed framework addresses this through a rules-based equilibrium architecture. Instead of relying on periodic, discretionary interventions, system responses are predefined and triggered automatically through:

- Dynamic blending thresholds
- Price stabilisation mechanism
- SAF diversion pathway for surplus absorption
- Coordinated decision-making across stakeholders.

This design ensures that ethanol utilisation can adjust in line with market conditions, scaling when crude prices rise, moderating during low-price environments, and redirecting excess supply when needed. The outcome is a more predictable and responsive system where producers gain demand visibility, OMCs can plan infrastructure more efficiently, and consumers benefit from partial insulation against global price shocks.

The shift is therefore from a discretionary system to one anchored in design where outcomes are shaped by predefined rules rather than periodic intervention.

At the same time, operational constraints for OMCs suggest that a transition toward source-agnostic ethanol pricing could help simplify procurement and reduce administrative complexity. However, a fully market-determined pricing regime may introduce volatility, given exposure to both agricultural feedstock cycles and global fuel price movements. A hybrid model that combines pooled procurement mechanism with a calibrated price-stabilisation layer can enable market-based price discovery while managing extreme fluctuations. This approach allows the system to move toward a market-oriented framework without losing the ability to use ethanol as a stabilising lever within the broader fuel economy.



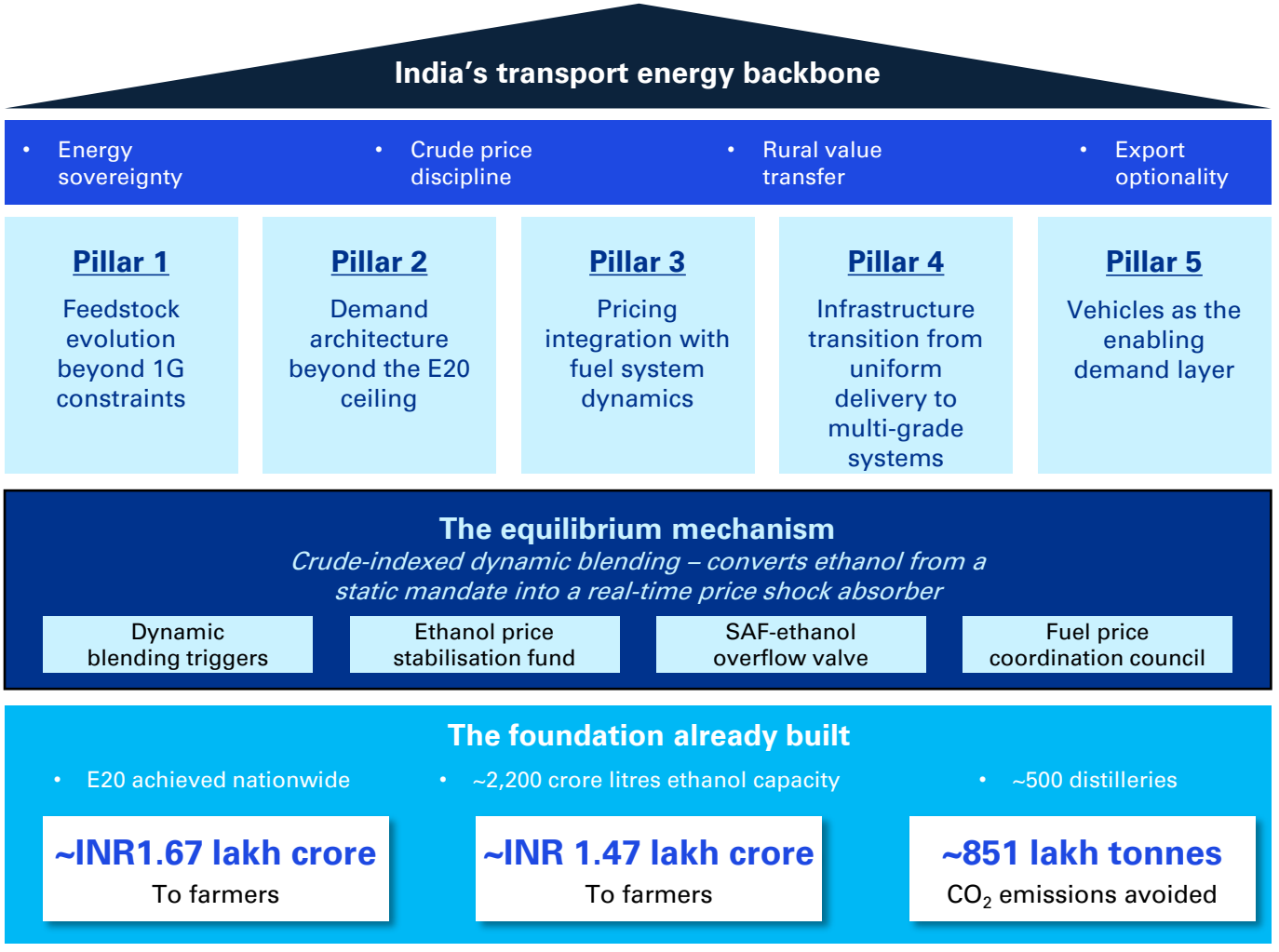
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Conclusion: The instrument India already owns

Few countries with a structural fuel import dependence possess a domestically produced, industrially scalable, and retail-distributable alternative already embedded within their transport system. India does. Over the past decade, the ethanol blending programme has established this foundation, achieving scale ahead of schedule, while delivering measurable gains in foreign exchange savings, rural income support, and emissions reduction.

The question now is how this asset can be strategically leveraged going forward. Early developments, including the introduction of flex-fuel vehicles and initial rollout of higher-blend fuel infrastructure, indicate that this transition is beginning to take shape. The central issue is no longer the extent to which ethanol can be blended, but how its role can be structured within the transport fuel system to reduce the impact of future crude price shocks on inflation and fiscal balances.

The framework set out in this paper brings together a coherent system architecture anchored in the foundation already built, the equilibrium mechanism at its core, the operational pillars that sustain it, and the backbone role that emerges as these components align. Together, they point to a transition from a static blending mandate to a more adaptive fuel system, one in which ethanol moves beyond incremental substitution toward a system-level function.



Sources: Government of India (Rajya Sabha – Unstarred Question)[36], ANI[37], BioEnergy Times[38]

36. Achievements of the Ethanol Blended Petrol (EBP) Programme, Government of India (Rajya Sabha – Unstarred Question), dated 09.03.2026
37. India likely to introduce diesel-isobutanol blending mandate this year to boost energy security, ANI, dated 29.05.2026
38. ESY 2024-25: Ethanol blending reaches 749 crore litres till July, BioEnergy Times, 14.08.2025

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Three shifts underpin this transition. First, the supply base must move beyond a 1G-dominated model, with future growth increasingly dependent on 2G and non-food feedstocks to scale sustainably. Second, pricing must evolve from a fixed, administered benchmark to a hybrid framework that balances market alignment with calibrated stabilisation to manage volatility. Third, the vehicle ecosystem must transition from compatibility at E20 to capability for higher blends, enabling incremental demand to materialise.

This positions the equilibrium mechanism not as a subsidy tool, but as a structural system design that uses India's existing ethanol capacity, agricultural base, and fuel infrastructure to create a domestic buffer against crude volatility.

India has already demonstrated the ability to bring together multiple stakeholders to deliver complex transitions at scale. This execution capability, combined with a strong commitment to sustainability and a proven track record of implementing large-scale system transformations, provides a solid foundation for the next phase beyond E20.

With the foundational elements in place and early deployments already underway, India is well positioned to scale ethanol from its current role into a central backbone of transport fuel economics, strengthening resilience while advancing its long-term energy transition goals.



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Glossary

Acronym	Full Form
ATF	Aviation Turbine Fuel
ATJ	Alcohol-to-Jet
BIS	Bureau of Indian Standards
BPCL	Bharat Petroleum Corporation Limited
BSFC	Brake-specific fuel consumption
CCEA	Cabinet Committee on Economic Affairs
CNG	Compressed Natural Gas
EBP	Ethanol Blended Petrol
ESY	Ethanol Supply Year
EV	Electric Vehicle
FADA	Federation of Automobile Dealers Associations
FRP	Fair and Remunerative Price
FFV	Flex-Fuel Vehicle
GST	Goods and Services Tax
HPCL	Hindustan Petroleum Corporation Limited
ICAO	International Civil Aviation Organisation
ICCT	International Council on Clean Transportation
KLPD	Kilo Liters Per Day
LNG	Liquified Natural Gas
MSW	Municipal Solid Waste
NRL	Numaligarh Refinery Limited
OEM	Original Equipment Manufacturer
OMC	Oil Marketing Company
OPEC	Organization of the Petroleum Exporting Countries
PIB	Press Information Bureau
SAF	Sustainable Aviation Fuel
UCO	Used Cooking Oil
IOCL	Indian Oil Corporation Limited
1G	First Generation
2G	Second Generation

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Throughout its development, the report has been shaped by a structured approach, with inputs focused on refining key themes, strengthening the analysis, and improving coherence in the overall narrative. Each contributor has played a role in shaping the final output, from early framing to the final articulation of insights.

The report reflects a shared commitment to presenting a coherent and forward-looking perspective on the evolving role of ethanol within India's transport fuel system.

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